SpaceOps 98 - Abstract

Title: Turbo Codes and Space Communications
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It is just over a quarter century since the launch of NASA's Pioneer 9 spacecraft on the first deep-space mission that relied on error-correcting codes to enhance scientific data return. The success of that first coding system spawned a continuous sequence of improvements in channel coding. Concatenated coding systems composed of an inner convolutional code and an outer Reed-Solomon code have been successfully used in deep-space missions for over a decade and have been incorporated in CCSDS standards for space telemetry systems. However, in order to obtain even higher coding gains, the decoder at the ground station becomes such a complex device that further improvements within this class of codes are extremely expensive.

The progress in the development of new, more powerful codes has been hampered because: good codes are hard to find, they are hard to analyze, they are hard to decode. Coding theorists have traditionally attacked the problem by developing codes with a lot of structure which lends to feasible decoders, although coding theory suggests that codes chosen "at random" should be pretty good if their block size is large enough. The challenge to find practical decoders for "almost" random, large codes had not been seriously considered until recently.

This talk discusses a new answer to these problems: a class of parallel and serial concatenated recursive codes, often called "turbo codes", which achieve near-Shannon-limit error correction performance with low decoding complexity. The reasons for the exceptional performance of these codes are explained, together with the basic structure of encoders and decoders. The role of these new codes in CCSDS activities to define a new coding standard for space telemetry is discussed, and the proposed codes and related open issues are addressed.

Finally, recent developments in this field are discussed, including: extensions of turbo codes to hybrid and self-concatenated structures, turbo trellis coded modulation for bandwidth efficient transmission, turbo codes with small latency, interleaver design, analytic performance bounds, and very low complexity turbo codes for high speed decoding.